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Studies on the Ecology of *Drosophila* in the Yosemite Region of California. V. A Preliminary Survey of Species Associated with *D. pseudoobscura* and *D. persimilis* at Slime Fluxes and Banana Traps

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Four species of the *pseudoobscura* subgroup of *Drosophila* occur in the western part of the United States: *D. pseudoobscura, D. persimilis, D. miranda,* and *D. frolovae.* Practically nothing is known about the last, but the first three species have received considerable attention from the standpoint of genetics, and of these, the first two have been intensively studied from the point of view of population structure, both in the field and in the laboratory.

Information on the ecology of *D. pseudoobscura* and *D. persimilis* has not been ignored, but it has been restricted to aspects such as diurnal periodicity, migration, estimates of population size, seasonal cycles, and food preferences (Dobzhansky and Epling, 1944; Dobzhansky and Wright, 1943; and da Cunha *et al.*, 1951), all of which can be observed or inferred simply by collecting these flies with the aid of traps. Further ecological data on these species could hardly be obtained without the knowledge of their natural breeding sites. This critical gap in information was filled by Carson (1951), who discovered that, at least in the Mather region of California, these species utilize the infected sap exudations (slime fluxes) of *Quercus kelloggii*, the California black oak, as feeding and breeding sites (Figs. 1 and 2).

With the discovery of the breeding and feeding sites of these two species of *Drosophila* it has been possible to investigate various problems bearing further on the ecology of these fruit flies: Cooper and Dobzhansky (1956) have reported on the relative abundance of 14 species of *Drosophila* known to occur at Mather and at other localities of the Yosemite region; Phaff *et al.* (1956) have described the yeasts found in the alimentary canal of *Drosophila*, and Carson *et al.* (1956) the various yeasts found in exudations of the black oak and other species of trees; Dobzhansky *et al.* (1956), by exposing traps inoculated with cultures of yeast isolated from the digestive tract of several species of

Drosophila and from slime fluxes, have expanded the data on attractivity of the various species of yeast to populations of various species of *Drosophila* inhabiting the Mather and Aspen localities.

The purpose of the present paper is to fill yet another gap in information available regarding natural populations of *Drosophila pseudoobscura* and *D. persimilis*, namely, the position of these fruit flies in the general biota of a particular area. For this purpose, arthropods occurring at oak slime fluxes in the Mather locality of California have been collected, where possible the behavior of the organisms recorded, and their feeding habits checked. It is hoped that such studies may reveal which are the predators, competitors, and associates of *Drosophila*, and perhaps lead to a solution of a paradoxical situation, namely, the apparent lack of competition between *Drosophila* and other organisms, inferred from the relatively large size of flies collected in the field as compared with the size of flies produced by larvae known to be at competition densities (Sokoloff, 1955).

Since *D. pseudoobscura* and *D. persimilis* are known to occur in areas where the California black oak or other oaks are absent, a parallel study has been made of forms attracted to banana traps, to ascertain to what extent the banana trapped material resembles the material trapped from the natural breeding sites of *Drosophila.*

Materials and Methods

The material for this investigation was collected in several localities in the Yosemite region of California. Two of these, Mather and Timberline, have already been described in the first paper of this series by Cooper and Dobzhansky (1956). The third locality, here referred to as Mono Lake, is situated about 20 miles south of Lee Vining, California, approximately 1 mile south of the Big Springs campground. The coniferous forest of this area belongs to the Transition life zone, consisting exclusively of *Pinus jeffreyi.* It is located at an altitude of 8,000 feet, in the Inyo National Forest.

Several methods were used to obtain the material. Banana traps were used in all collecting areas. Fermented banana mash was introduced into plastic cups, and these were placed on wire ring stands near the

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Explanation of Figures

Fig. 1 (upper), The trunk of *Quercus kelloggii* showing the characteristic stain which appears after the tree begins to exude sap. Fig. 2 (lower), A close-up of the site from which sap flows. This slime flux was suitable to *Drosophila* as a breeding place.

trunk, on the shady side of trees. Flies attracted to this medium were transferred to vials with the aid of a glass funnel. This method did not work on beetles, since they tended to drop to the ground or to the bottom of the cup when they were disturbed. They were extricated from the medium by any means available, but usually with the aid of forceps.

The rest of the collection was obtained from slime fluxes. Adult Diptera visiting these sites were trapped with a shell vial. Fairly large arthropods were collected by hand, others with the aid of forceps. It is evident that such methods of collection were highly inefficient, but they permitted observations on the behavior of the various organisms before capturing them.

Other material was obtained after removing part of the bark around the slime flux and some of the slime. In the laboratory, both the bark and the slime were examined with the aid of a dissecting microscope. Some of the larvae and small adult arthropods were preserved immediately. Other larvae were allowed to complete their development, and the emerging adults were subsequently preserved. Part of the slime served as bait in the capture of some flies. At dusk, it proved especially attractive to nematocerans of the families Lycoriidae (Sciaridae) and Psychodidae. This slimy material also proved to be an excellent nutrient medium: in plugged shell vials containing this substance, rich cultures of nematodes, collembolans, and several species of mites developed in a few weeks.

Results

Of far the greatest interest is the Mather material since it was collected over a period of nearly 3 months and it originated from slime fluxes and traps, whereas the material from other areas was collected strictly from banana traps, and only during brief collecting periods, not more than a week at a time at the collecting sites.

Even at Mather the material from the two sources (traps and fluxes) is not strictly comparable: the traps were not placed directly on the ground, they were exposed only late in the afternoon when the fruit flies were active, and they varied in the freshness and moisture content of the bait. Material from the slime fluxes, on the other hand, was collected at any (free) time of the day except late in the afternoon when *Drosophila* are attracted to traps.

However, the primary interest (at least in this preliminary survey) is in the qualitative aspects of the fauna attracted to the two sources of food; therefore, the differences in the time of day when the material was collected are not taken into account. It might be pointed out that *D. pseudoobscura* and *D. persimilis* are not attracted to banana traps in

the middle of the day but they come to them in the early morning and late afternoon (see Dobzhansky and Epling, 1944). On the other hand, these fruit flies have been seen at slime fluxes at all times of the day, but they disappear as darkness falls. Thus, it has been possible to observe the behavior of these insects and their associates in their natural surroundings.

It is evident from Table 1 that there are considerable differences between the forms collected from slime fluxes and by means of banana traps. This is not unexpected, since the traps were set off the ground, preventing most crawling forms from reaching the trap. Furthermore, the traps were exposed only for a few hours of the late afternoon. Nevertheless, there are similarities in the type of insects attracted to both traps and sap fluxes: two species of Formicidae (*Camponotus* and *Liometopum*); one species of nitidulids (*Colopterus truncatus*), and several genera of Diptera (*Aulacigaster, Dasyhelea, Helina, Megaselia, Minettia,* and *Myospila*). The species of *Drosophila* known to be attracted to both sap fluxes *and* banana traps are *D. pseudoobscura, D. persimilis, D. californica, D. victoria, D. subfunebris, D. pinicola,* and *D. busckii* (Carson, 1951, and personal observations).

A large number of genera have been collected only from slime fluxes: two genera of ants (*Leptothorax* and *Crematogaster*); seven genera of beetles (*Holciophorus, Eleodes, Melanotus, Enicmus, Nosodendron, Aliochara,* and *Atheta*); and 13 genera of flies (*Scythropochroa, Bradysia, Mycetaulus, Pericoma, Telmatoscopus, Periscelis, Eucalliphora, Phormia, Ravinia, Forcipomya,* a species near *Culicoides,* a tendipedid, and *Coenosia*). No species of *Drosophila* is known to be attracted only to slime fluxes.

Much of the material obtained from slime fluxes consisted of nonflying forms. Some of the insects were found in the slime itself, others outside or in the immediate vicinity of the slime. The organisms collected and listed in the table were all in the vicinity of the slime flux, not more than 1 inch on either side of the flow of sap. It was noted that, concealed in the crevices of the bark where the sap flowed and the humidity was high, were the chilopods *Ethopolis* (Cryptopidae) and *Theatops* (Lithobiidae); on the bark near the flux were the spiders *Metaphidippus* (Attidae), *Coriarachne,* and *Misumenops* (Thomisidae). Immature spiders such as *Meioneta* and *Spirembolus* (Linyphiidae), and *Euryopis* (Theridiidae), had built their webs on the crevices near or over the slime fluxes. The lathridiid *Enicmus,* springtails of the family Entomobryidae, the corrodentian *Liposcelis,* and pseudoscorpions of the tribe Chernetinae were found in the interstices of the bark

Table 1. Fauna (exclusive of *Drosophila*) collected by means of banana traps or from slime fluxes in the three localities in the Yosemite and Mono Lake regions of California.

Organism	Locality			
	Mather		Timberline	Mono Lake
	Flux	Trap	(Trap)	(Trap)
NEMATODA	x			
CHILOPODA				
Cryptopidae				
Ethopolis xanti (Wood)	x			
Lithobiidae				
Theatops erythrocephalus californicus Chamberlain?	x			
ARACHNIDA				
ACARINA				
Tarsonemidae				
Tarsonemus sp.	x			
Canestriniidae				
Genus?	x			
Oribatulidae				
Liebstadia sp.	x			
Urodinychidae				
Leiodinychus sp.	x			
Anoetidae				
Histiostoma sp.	x			
CHELONETHIDA				
Tribe Chernetinae (immature)	x			
ARANEIDA				
Attidae				
Metaphidippus aeneolus Curtis	x			
Thomisidae				
Coriarachne versicolor Keyserling			x	
Misumenops californicus Banks (immature)	x			
Linyphiidae				
Meioneta sp. (immature)	x			
Spirembolus sp. (immature)	x			
Theridiidae				
Euryopis formosus Banks	x			
INSECTA				
COLLEMBOLA				
Entomobryidae				
Genus?	x			
BLATTARIA				
Blattidae				
Parcoblatta americanica (Scudd.)	x	x		

Table 1 (*continued*)

Organism	Locality			
	Mather		Timberline	Mono Lake
	Flux	Trap	(Trap)	(Trap)
ORTHOPTERA				
Tettigoniidae				
Pristoceuthophilus pacificus (Thomas)	x			
Gammarotettix cyclocercus Hebard	x			
PSOCOPTERA = (CORRODENTIA)				
Liposcelidae				
Liposcelis sp.	x			
HEMIPTERA				
Lygaeidae				
Eremocoris inquilinus Van D.	x			
DIPTERA				
Psychodidae				
Pericoma sp.	x (L) *			
Telmatoscopus sp.	x			
Chironomidae = (Tendipedidae)	(L)			
sp. of Pelopiinae				
Ceratopogonidae = (Heleidae)				
Forcipomya sp.	(L)			
Dasyhelea sp.	(L)	x		
Genus near *Culicoides*	(L)			
Sciaridae = (Lycoriidae)				
Scythropochroa sp.	x			
Bradysia sp.	x			
B. fenestralis (Zett.)	x (L)			
Cecidomyiidae = (Itonididae)				
Tribe Itonidini			x	
Phoridae				
Megaselia sp.	x (L)		x	
Calliphoridae				
Eucalliphora lilaea (Walk.)	x			
Phormia regina (Mg.)	x			
Calliphora livida Hall				x
Sarcophagidae				
Ravinia lherminieri (R-D)	x			
Muscidae				
Helina sp.	x	x		
Fannia sp.		x		
Muscina sp.		x		x
Muscina sp. (*aurantiaca* Hough?)				x
Paregle cinerella (Fall.)		x	x	x
Pegomya affinis (Stein)		x		

* (L) = Larvae.

Table 1 (*continued*)

Organism	Locality			
	Mather		Timberline	Mono Lake
	Flux	Trap	(Trap)	(Trap)
Myospila meditabunda (F.)	x	x		x
Morellia micans (Macq.)		x		
Schoenomyza dorsalis sulfuriceps Mall.		x		
Hylemya alcathoe (Walk.)		x		
Hylemya cilicrura (Rond.)		x	x	x
Hylemya fascialis Mall.	x			
Hylemya sp.		x	x	x
Hylemya cerealis (Gill)			x	x
Coenosia sp.	x			
Lonchaeidae				
Lonchaea sp.				x
Heleomyzidae				
Suillia barberi Darl.			x	
Piophilidae				
Mycetaulus bipunctatus (Fall.)	x			
Piophila (*sensu latu*) sp.			x	
Lauxaniidae				
Minettia flaveola Coq.	x	x		x
Periscelididae				
Periscelis sp. n.	x			
Aulacigasteridae				
Aulacigaster leucopeza Mg.	x(L)	x		x
Sphaeroceridae (Borboridae)				
Leptocera sp.			x	
COLEOPTERA				
Carabidae				
Holciophorus ater Dej.	x			
Staphylinidae				
Aliochara (*sensu latu*)	x			
Atheta sp. A.	x			
Atheta sp. B.	x			
Atheta (*sensu latu*) sp. C	x			
Elateridae				
Melanotus sp.	x			
Limonius humeralis Cand.		x		
Nosodendridae				
Nosodendron californicum Horn	x			
Nitidulidae				
Colopterus truncatus (Rand)	x	x		
Carpophilus discoideus Lec.		x		
Carpophilus hemipterus (Linn.)		x		
Epuraea sp. (*terminalis* Mann?)		x		

Table 1 (*continued*)

Organism	Locality			
	Mather		Timberline	Mono Lake
	Flux	Trap	(Trap)	(Trap)
Lathridiidae				
Enicmus sp.				
Tenebrionidae				
Eleodes sp.	x			
HYMENOPTERA				
Ichneumonidae				
Zaleptopygus sp. ♂			x	
Pteromalidae				
Halticoptera sp.			x	
Platygasteridae				
Isostasius sp.		x		
Formicidae				
Camponotus vicinus Mayr	x	x		x
Liometopum occidentale Em.	x	x		
Leptothorax rugatulus Em.	x			
Crematogaster sp.	x			
Formica sp. *fusca* group			x	

near the slime. The ants *Camponotus, Liometopum*, and *Leptothorax* were seen in long columns; their paths often disappeared in the crevices of the bark which served as channels for the sap flows. Some insects were collected while they were drinking the sap exudations: *Parcoblatta* (Blattidae), *Gammarotettix* and *Pristoceuthophilus* (Tettigoniidae), *Melanotus* (Elateridae), *Holciophorus* (Carabidae), *Eleodes* (Tenebrionidae), and *Eremocoris* (Lygaeidae).

Within the slime were found adults and larvae of *Nosodendron californicum* (Nosodendridae) (Sokoloff, 1960), many nematodes (unclassified because they were improperly preserved), five families of mites (Tarsonemidae, Canestriniidae, Oribatulidae, Urodinychidae, and Anoetidae), and many Diptera larvae assigned to the following genera: *Bradysia* (Sciaridae), *Megaselia* (Phoridae), *Pericoma* (Psychodidae), *Aulacigaster* (Aulacigasteridae), *Forcipomya, Dasyhelea*, and a genus near *Culicoides* (Ceratopogonidae = Heleidae), a genus of Pelopiinae (Chironomidae), and an unidentified muscid pupa. In addition, eggs, larvae, and pupae of *D. pseudoobscura, D. persimilis, D. victoria*, and *D. californica* have been identified to species by Carson by rearing them to adults.

While some species have been collected only by banana traps and

some only from slime fluxes, the presence of an insect, say, in the trap collection, but absent from the slime flux collection should be given little significance. It may only mean that the insect and the collector did not visit the slime flux at the same time. Thus, for example, *Colopterus discoideus, Carpophilus hemipterus*, and *Epuraea* are nitidulids and, requiring sap for feeding and breeding, should have been collected at slime fluxes. Also, among the Drosophilidae, *D. miranda* is closely related to *D. pseudoobscura* and *D. persimilis*. Hence, it probably uses slime fluxes for feeding and breeding. Its absence from the slime flux collection may merely reflect the low population density of this species in the Mather area.

On the other hand, the presence of an insect in association with others at banana traps does not necessarily mean that the two must exploit the same niche: *D. azteca* is the most abundant species at banana traps, outnumbering *D. pseudoobscura* and *D. persimilis*. Were it at all attracted to slime fluxes, it would have been captured even with the crude methods of collection used. Thus, it is fairly certain that *D. azteca* must occupy a niche different from that occupied by *D. pseudoobscura* or *D. persimilis* in the Mather area.

Discussion

With the information presented above, and the food habits of the organisms reported in the literature, it is possible to build a tentative food web as shown in Fig. 3.

The primary source of energy is provided by the tree, which secretes the sap. This liquid, rich in carbohydrates, becomes infected with numerous species of bacteria, yeasts, and fungi. Carson *et al.* (1956) have reported the isolation of several hundred pure cultures of bacteria which remain unidentified. Nothing is known at present of the types of fungi involved in the complex microflora of the slime, but considerable information is available on the various species of yeasts found in the sap exudations of several species of trees and in the crops of *Drosophila*. Thirteen species of yeast have been isolated from the crops of fruit flies and 14 species from oak sap fluxes. It has been noted by Carson and collaborators that the yeasts found in the digestive tract of flies are different from those in exudations of sap where flies were breeding.

On the complex microflora growing in the sap feed larvae of four species of *Drosophila* (*D. pseudoobscura, D. persimilis, D. victoria*, and *D. californica*) and the adults of these and three more species (*D. subfunebris, D. pinicola*, and *D. busckii*). Other herbivores found in the

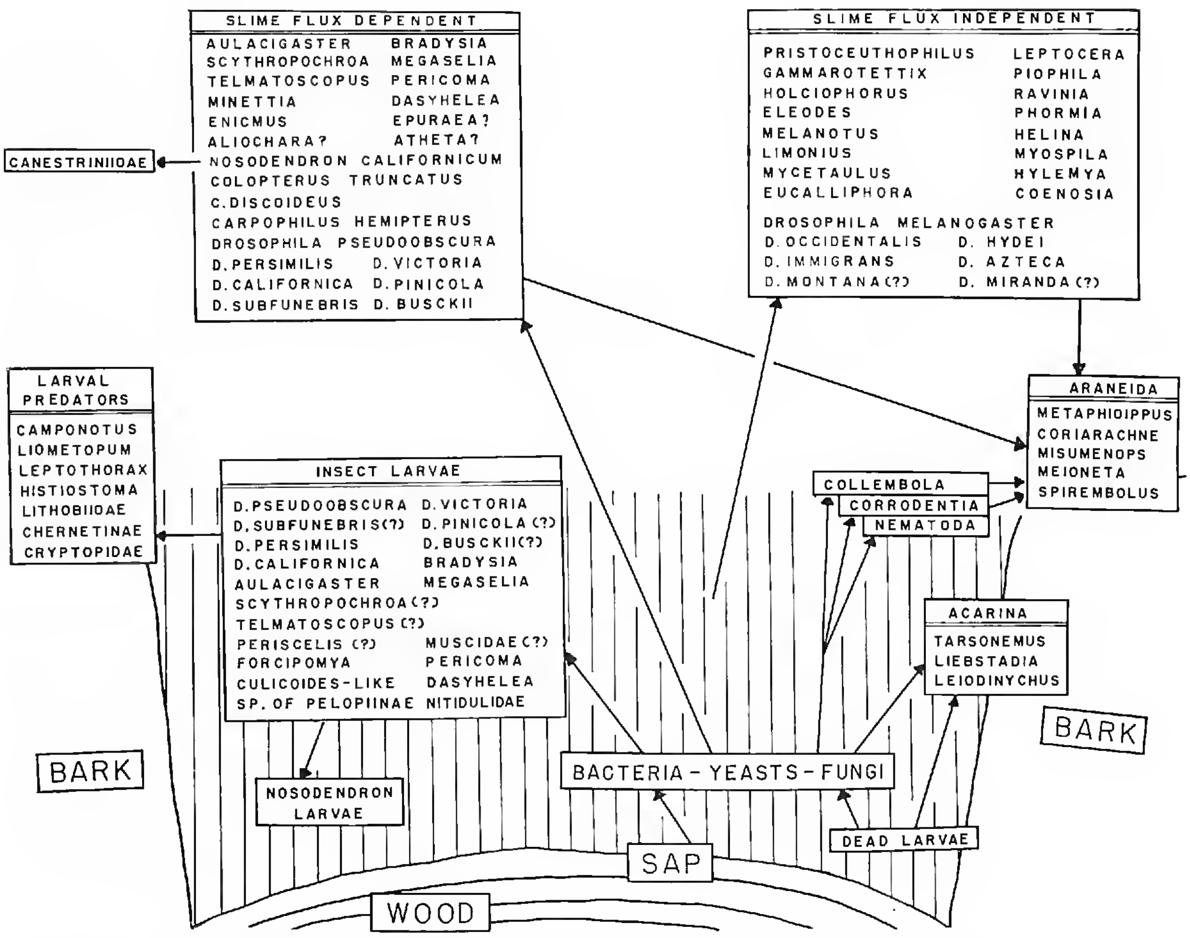

Fig. 3. A tentative scheme of the biocoenosis of *Quercus kelloggii* slime fluxes.

slime include nematodes, Acari (tarsonemid, oribatid, and urodinychid mites), some primitive insects (Collembola and Corrodentia), and families of the more advanced Coleoptera (nitidulids) and Diptera. Although no quantitative data are available, it can be stated that larvae of the dipteran families Sciaridae and Aulacigasteridae are found in large numbers; larvae of *Drosophila*, Phoridae, Psychodidae, and Heleidae are found in much smaller numbers. In addition, adults of all these families and adults of Lauxaniidae, Periscelidae, and Chironomidae have been collected while feeding on the sap of the tree. All these organisms have been entered under the heading of "slime flux dependent" in the figure, but simply for convenience. The habits of these organisms vary, but they have in common the fact that they can exploit the slime flux habitat. Those organisms which obviously occupy other niches during their development but which were apparently present in the flux to replenish fluids have been entered under the heading of "slime flux independent" again purely for convenience. Predators such as spiders belong to the latter category, but they are placed in a separate group in the slime flux biocoenosis to emphasize the fact that both slime flux "dependent" and "independent" forms are used as food.

Although some of the slime flux dependent organisms may prefer to feed on bacteria, others on fungi, and still others on yeasts, the consistency of the slime is such that neither adults nor larvae are able to consume one microorganismic species to the exclusion of all others. It it more likely that both adults and larvae exploit a mixture of these organisms as food. As a result, the various species found in slime fluxes could enter into competitive relationships for the food available. Such events must occur but seldom for *Drosophila*, and only when the microenvironment where eggs and larvae are found is in the process of drying.

This can be the most likely explanation for the following paradoxical situation:

1. *Drosophila* populations can reach a large size. Periodic collections of fruit flies at Mather by Cooper and Dobzhansky from June to September 1954, yielded a total of 42,000 flies of 14 species of *Drosophila* and nearly 1,000 *Aulacigaster* in banana traps. This represents but a small sample of Drosophilidae in the area since collections were not made every day. Of the ten species native to the area, *D. pseudoobscura* and *D. persimilis* were the most abundant after *D. azteca.* We may ignore the last mentioned species, since the slime flux is not its habitat niche.

2. Laboratory studies show that *Drosophila* is a very fecund insect. Under favorable conditions, a single female may produce over a thousand offspring. It would be expected that, if slime fluxes provided similar conditions as a culture bottle, large numbers of larvae would be found in a single slime flux. This expectation fails to materialize: when the slime flux is examined, few larvae (of the order of a few dozen) are found.

3. Other laboratory experiments (for example, Sokoloff, 1955) designed to study intraspecies and interspecies competition at various densities and temperatures have led to the finding that, when competition densities are reached, the weight, hence the size of the flies, drops to the same extent regardless of the temperature conditions. On the other hand, at low densities flies reared at the lower temperature are always heavier.

Now, *Drosophila* captured in nature are much larger than flies reared in vials under severe competition conditions. This suggests that the flies, during their developmental stages, find sufficient food. Putting it in other words: despite the large populations of adults, their high fecundity, and the availability of breeding sites, few females apparently succeed in reaching them to lay their eggs.

It would appear that for *Drosophila* the problem of finding a suitable feeding or oviposition site is far simpler than utilizing it. It has been observed repeatedly by the writer that the larger insects (especially flies) frequenting the slime fluxes exhibit aggressive movements toward the smaller Diptera. The random movements of insects, as observed by Carson and Stalker (1951) in the case of ants, have the same effect. *Drosophila* and other small insects are forced to fly off to another spot of the tree. When this happens repeatedly, the feeding or egg-laying activities of the flies are interrupted.

A further obstacle to adults is presented by spiders. How large a role these animals play in the destruction of fruit flies should not be difficult to ascertain, since some spiders build their webs on the seemingly more attractive part of the slime flux. The net result, however, is that many *Drosophila* females are destroyed before they have an opportunity to lay eggs. Those that escape predation or interference by other members of the biota probably are underfed and lay very few eggs.

Once the eggs are laid, there is no guarantee that they will hatch. It has been observed that some are buried by other larvae and drown in the slime. If the larvae emerge, a further diminution in the population results through the predatory activities of chilopods, pseudoscorpions, mites, ants, adults and larvae of *Nosodendron,* staphylinids, and perhaps other Coleoptera, especially small carabids. In addition, larvae may serve as oviposition sites for some of the small wasps.

Competition, according to Crombie (1947), may be prevented in three ways: by the organism itself, by the physical environment, or by the biotic environment. The first point gains support from the findings by Carson and collaborators (1956) that adults of *Drosophila* utilize one type of slime flux for feeding and another for breeding. Thus, intraspecies competition between larvae and adults of one species does not occur. The second point is sufficiently documented to hold for all insects, since during severe winters or drouth their populations are greatly reduced. The third point needs further substantiation in the case of *Drosophila.* For the present, on the basis of the fauna collected from slime fluxes, the following working hypothesis is suggested: the chief biotic factors responsible for keeping populations of *Drosophila* under control are those organisms identified as predators and associates. Through their activities, they minimize the number of eggs and larvae in a given breeding site and thus make it possible for fruit flies to develop usually with a minimum of competition.

The banana trap must be used with caution in the test of the hypothesis: although many insects have proved to be attracted to both banana

traps and slime fluxes, and many of those recorded so far from baited traps may prove to visit sap exudations, it cannot be assumed that all species will. For example, Carson (1951) has shown that *D. azteca* is about equally abundant as *D. pseudoobscura* and *D. persimilis* in traps, and yet it has never been taken from oak wounds. For this reason, where the habitat niche of *Drosophila* is known, collections of associated biota should be made directly from it. Where the microhabitat occupied by *Drosophila* species is not known, banana traps provide the only method of learning which species *may* coexploit the same breeding and feeding sites, and the feeding habits of these organisms as reported in the literature may help decide whether they are doing so as competitors or as associates. The traps will also show which may be some of the predators of *Drosophila*, since some Hymenoptera and other carnivorous insects are attracted to them.

Summary

1. A preliminary qualitative survey of organisms frequenting slime fluxes (sap exudations infected with microorganisms) of *Quercus kelloggii*, the California black oak, has been carried out in the Mather region of California. A parallel collection has been made with the aid of banana traps at Mather and at two other localities of the Yosemite region.

2. Comparison is made of the adult insect fauna attracted to slime fluxes and banana traps. The conclusion is made that these traps are useful in detecting the forms which may coexploit the same sources of food and some of the predators of *Drosophila* (provided that due consideration is given to the feeding habits of these organisms as reported in the literature) in areas where the habitat niche of species of this genus is unknown.

3. On the basis of the feeding habits of the fauna collected at slime fluxes a tentative food web of the complex biocoenosis of the slime flux is included.

4. The role of these organisms in relation to *Drosophila* is discussed. As a working hypothesis, it is suggested that, of the slime flux biota, predators and associates are the main biotic factors preventing the excessive oviposition by *Drosophila* at the slime flux. As a result, it is probable that competitive relationships between the various organisms associated with *Drosophila* in the exploitation of the slime flux seldom take place.

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Literature Cited

Allee, W. C., A. E. Emerson, O. Park, T. Park, and K. P. Schmidt. 1949. Principles of animal ecology. W. B. Saunders, N. Y. 837 pp.

Baker, E. W. 1952. An introduction to acarology. The Macmillan Co., N. Y. 465 pp.

Brues, C. T. 1946. Insect dietary; an account of the food habits of insects. Harvard University Press, Cambridge. 466 pp.

Carson, H. L. 1951. Breeding sites of *Drosophila pseudoobscura* and *Drosophila persimilis* in the Transition zone of the Sierra Nevada. Evolution, 5: 91–96.

Carson, H. L., E. P. Knapp, and H. J. Phaff. 1956. Studies on the ecology of *Drosophila* in the Yosemite region of California III. The yeast flora

of the natural breeding sites of some species of *Drosophila*. Ecology, 37: 538–544.

COOPER, D. M., AND TH. DOBZHANSKY. 1956. Studies on the ecology of *Drosophila* in the Yosemite region of California I. The occurrence of species of *Drosophila* in different life zones and at different seasons. Ecology, 37: 526–533.

CROMBIE, A. C. 1947. Interspecific competition. Jour. An. Ecol., 16: 44–73.

DA CUNHA, A. BRITO, TH. DOBZHANSKY, AND A. SOKOLOFF. 1951. On food preferences of sympatric species of *Drosophila*. Evolution, 5: 97–101.

DOBZHANSKY, TH., D. M. COOPER, H. J. PHAFF, E. P. KNAPP, AND H. L. CARSON. 1956. Studies on the ecology of *Drosophila* in the Yosemite region of California IV. Differential attraction of species of *Drosophila* to different species of yeasts. Ecology, 37: 544–550.

DOBZHANSKY, TH., AND C. EPLING. 1944. Taxonomy, geographic distribution and ecology of *Drosophila pseudoobscura* and its relatives. Carnegie Inst. of Washington Publ., 554: 183 pp.

DOBZHANSKY, TH., AND S. WRIGHT. 1943. Genetics of natural populations XV. Genetics, 32: 303–324.

PHAFF, H. J., M. W. MILLER, J. A. RECCA, M. SHIFRINE, AND E. M. MRAK. 1956. Studies on the ecology of *Drosophila* in the Yosemite region of California II. Yeasts found in the alimentary canal of *Drosophila*. Ecology, 35: 533–538.

SOKOLOFF, A. 1955. Competition between sibling species of the *pseudoobscura* subgroup of *Drosophila*. Ecol. Monographs, 25: 387–409.

1959. The habitat niche of American Nosodendridae. Coleopterists' Bull., 13: 97–98.

Two Scavenger Moths of the Genus *Borkhausenia* Introduced from Europe to the West Coast of North America

(Lepidoptera : Oecophoridae)

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During the past several years specimens of a small, tan moth have appeared commonly in material I have examined from the San Francisco Bay area, and recently light trap collections have produced a related yellow and reddish moth. These represent two species of the genus *Borkhausenia* (*sens. lat.*) which were not recorded in the North American fauna by Clarke (1941).

BORKHAUSENIA (BORKHAUSENIA) FUSCESCENS (Haworth)

One of the first species I encountered when I began collecting microlepidoptera at Berkeley in 1955 was this moth, and it has appeared consistently in houses and at porch lights during subsequent years. *B.*

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